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## Request for grant of a patent

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| | | |
|---|---|---|
| 1. Your reference | HMJ03635GB | |
| 2. Patent application number *(The Patent Office will fill in this part)* | 0229110.2 | 13 DEC 2002 |
| 3. Full name, address and postcode of the or of each applicant *(underline all surnames)* | Ole-Bendt RASMUSSEN<br>Sagenstrasse 12<br>CH 6318 Walchwil<br>SWITZERLAND | |
| Patents ADP number *(if you know it)* | 6506337003 | |
| If the applicant is a corporate body, give the country/state of its incorporation | | |
| 4. Title of the invention | Laminates of films having improved resistance to bending in all directions and methods and apparatus for their manufacture | |
| 5. Name of your agent *(if you have one)* | Gill Jennings & Every | |
| "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* | Broadgate House<br>7 Eldon Street<br>London<br>EC2M 7LH | |
| Patents ADP number *(if you know it)* | 745002 | |

| 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number | Country | Priority application number *(if you know it)* | Date of filing *(day / month / year)* |
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| 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application | Number of earlier application | Date of filing *(day / month / year)* |
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| 8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*<br>*a) any applicant named in part 3 is not an inventor, or*<br>*b) there is an inventor who is not named as an applicant, or*<br>*c) any named applicant is a corporate body.*<br>*See note (d))* | NO |

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| Continuation sheets of this form | |
| Description | 51 |
| Claim *(s)* | ~~17~~ 16. please see minute. |
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10. If you are also filing any of the following, state how many against each item.

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| Priority documents | |
| Translations of priority documents | |
| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | |
| Request for preliminary examination and search *(Patents Form 9/77)* | |
| Request for substantive examination *(Patents Form 10/77)* | |
| Any other documents *(please specify)* | ~~NO~~ |

11. For the applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date
13 December 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

H M M JONES
020 7377 1377

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Laminates of films having improved resistance to bending in all directions and Methods and apparatus for their Manufacture.

The present invention relates to a flexible laminate of films from thermoplastic polymer material mainly for applications in which relatively high yield strength and ultimate tensile strength is required, and a method and apparatus for its manufacture. In special aspects it also relates to film laminates which allow air but not water to penetrate, and laminates with properties as filter material.

Examples of applications are: tarpaulins and cover-sheets, pondliners, substitute of geotextiles, weather or gas protective garments, greenhouse film, industrial bags or garbage bags, carrier bags, self-standing pouches, and sanitary backsheets.

For economical reasons there is an increased need to reduce the square metre weight of flexible film made from thermoplastic polymer material. The limits are partly set by the required strength properties, and partly by the required self supporting capability, i.e. stiffness or resilience with respect to bending. These needs have mainly been met by selected developments of the thermoplastic polymer compositions and as far as the strength is concerned also by biaxial orientation, or by crosslamination of films each of which exhibits a generally monoaxial or unbalanced biaxial orientation.

From the strength point of view essential savings can be achieved by such orientation and/or crosslamination processes.

Thus as an example an industrial bag made from extruded polyethylene film of the best suited grades and destined for packing of 25 kg polyethylene granules must generally have a thickness of 0,12-0,15 mm in order to satisfy the normal strength requirements, while this thickness can be brought down to about 0,07 mm by use of optimized oriented and crosslaminated film from polyethylene, However, when this crosslaminate is made in the known manner, few available types of machines for manufacturing bags from film, and few available types of machines for filling the bags, can work adequately with film which is so thin and flimsy.

A crosslaminate which, besides the improved strength properties obtained by the orientation and crosslamination also by virtue of its geometrical structure shows significant improvements in this respect, is described in the inventor's earlier Specification EP-A-0624126.

This is a crosslaminate of a slightly waved configuration in which the material in the curved crests on one or both sides of the laminate is thicker than elsewhere, the material between these thicker curved crests being generally straightened out. (See Figs. 1 and 2 of said patent publications). The structure is obtained by stretching between several sets of grooved rollers under special conditions. This stretching also imparts transverse orientation. The disclosed wavelengths of the final product

are between 2,2 and 3,1 mm.

Crosslaminates according to the said patent have been produced industrially since 1995 for manufacture of industrial bags from combinations of high molecular weight high density polyethylene (HMWHDPE) and linear low desinty polyethylene (LLDPE) with film weight about 90 $gm^{-2}$, and the slightly waved shape in combination with the thicknened crests imparts a stiffness and resilience in one direction of the film which has proven to be very important for the performance of the bag machines with such relatively thin film. However, the film is not adequate for work with the 70 $gm^{-2}$ gauge which satisfies the strength requirements.

As another example an agricultural tarpaulin (e.g. for protection of crops) made from a 70 $gm^{-2}$ crosslaminate of oriented polyethylene films would be a fully adequate substitute of a 100 $gm^{-2}$ tarpaulin made from extrusion-coated woven tape, if only objective critieria were applied. However, in actual fact the average customer to agricultural tarpaulins makes his choise to a great extent on the basis of the "handle" and the appearance, and will reject the 70 $gm^2$ tarpaulin due to its flimsiness, judging that it lacks substance.
The stiffness can of course always be increased by suitable incorporation of a filler, (and the present invention includes that as an additional option) but this will always more or less be at the expense of puncture and tear propagation resistance, especially under impact actions.

Object of the present invention is to add a "feel of substance" and improve the stiffness or resilience of the film in all directions, without sacrificing the laminate's character of feeling and looking like a generally two-dimensional structure, and without essentially harming the puncture and tear propagation resistance.

The basic idea behind the present invention is to apply the corrugated paperboard principle to laminates of thermoplastic films, but preferably in such a way that the flute structure is made especially fine ("minifluted"), so as to obtain a laminate which, in spite of the structurally increased stiffness still can satisfy the above mentioned conditions, and it is an essential feature of the invention that there are flutes in two different plies, with the flute directions criss-crossing to give all directions of the laminate increased stiffness or resilience. More precisely the product of the invention is specified in claim 1.

While I here have identified the laminate as comprising the plies A and B, each "ply" can consist of one or more "films", normally extruded films, and each extruded film can and normally will consist of several coextruded "layers".

In itself the application of the corrugated paperboard principle to thermoplastic film material is not new, but in the known art this is done by laminating a fluted film to a flat film, and furthermore the finest flute structure which has been disclosed in patent literature, namely in US-A-4132581 col. 6, ln. 66 is 50+/-3 flutes per foot

corresponding to a wavelength of about 6,0 mm. It must also strongly be doubted that a wavelength lower than this can be achieved by the method disclosed in the said patent, in which the first bonding process takes place under use of a row of many sealer bars supported and transported by a belt.

The sealer bars are transverse to the direction of movement (the machine direction) so the fluting also becomes perpendicular to this direction.

The use of the method of the said US patent is stated to be manufacture of board material, and the thickness of the fluted ply is indicated to be about 0,004-0,025 inches (0,10-0,625 mm). In the example it is 0,018 inches (0,45 mm). Other patents dealing with the use of the corrugated paperboard principle to thermoplastic film for the making of panels or boards are US-A-3682736, US-A-3833440, US-A-3837973, EP-A-0325780 and WO-A-94/05498.

Japanese Patent Application Hei 02,052732 discloses laminates consisting of a corrugated thermoplastic film bonded to a flat thermoplastic film, which on its other side is bonded to paper. (The paper and flat sheet are first joined and then the corrugated film is added). The flutes, which also in this case are perpendicular to the machine direction, are pressed flat and adhesively closed at intervals so that a large number of airtight vesicles are formed. The stated use of this product is for cushion material, sound insulating material, heat- and moisture-insulating material and wall decorative material. The thicknesses of the corrugated sheet and flat sheet are not

indicated, neither are the wavelength of the fluting and the length of the vesicles.

The inventor of the present invention has found that special constructions of the corrugator/laminator generally is needed in order to make the particular fine flutes ("miniflutes"), since if the pitch is low on the gear rollers which produce the fluting and the lamination, the corrugated film will tend to "jump out" of the grooves in the forming and laminating roller during its passage from the location where the forming of flutes takes place to the location where the bonding takes place. In a conventional corrugator for manufacture of corrugated paperboard there are provided tracks or shield to hold the fluted paper in the grooves. At ambient temperature this allows the paper to be more readily permanently formed.

Similar tracks or shields in unmodified form cannot be used with thermoplastic film under production conditions since friction against the track or shield quickly would create congestion by heating of the polymer.

An improved, frictionless way of holding of flutes of paper in the grooves of a roller is known from US-A-6139938, namely by maintaining a controlled underpressure within the grooves (see Figs. 9 and 10 and col. 7 lines 25-34). This US patent deals entirely with corrugated paper laminates having particularly low wavelength, while manufacture of corrugated structures from thermoplastic films is not mentioned.

However, the improved method of holding the flutes will in fact also, depending on the film thickness, be applicable to

fine flutes in thermoplastic film. This was found in connection with the development of the present invention.

The present development of the particularly fine flute structure, the "miniflutes", can be expected to make the corrugated paperboard principle applicable to completely different fields of use such as the fields mentioned at the very beginning of this specification.

This has comprised a development of new types of machinery based on grooved rollers with a very fine pitch. As it will apear from the example the wavelength in each ply of a 90 $gm^{-2}$. "minifluted" 2-ply laminate has in actual fact been brought down to 1,0 mm through a process which can be carried out industrially. Especially by use of after-shrinkage it can probably be brought further down e.g. to about 0,5 mm. The mentioned 90 $gm^2$ corresponds to an average thickness of about 0,096 mm if the laminate were pressed flat.

The invention is not limited to gauges corresponding to pressed-flat thicknesses around this value, but also comprises, very generally speaking, minifluted laminates of an average thickness in compacted form which is roughly about 0,3 mm or lower. Thicknesses down to about 0,03 mm or even lower can be made for special purposes, such as for instance back-sheets on napkins.

Nor is the invention limited to the use in connection with crosslaminates of oriented films. For different purposes

different combinations of strength properties are required. Crosslaminates can, as is known, be produced with suitable combinations of several categories of strength properties but for many purposes other types of strength laminates may be preferable when the cost of the manufacturing process also is considered, and the present invention can also be useful in such other strength laminates as it further shall be specified below.

By making the wavelength as low as about 5 mm or less, the laminate looses - gradually with the reduction of wavelength - its character of being a board material and gets appearance, handle and bending properties like a resilient flexible film. It also gets improved puncture and tear properties, relative to its weight.

Compared to non-corrugated laminates of the same composition and same square weight it feels much more "substantial" due to the increased stiffness and resilience in all directions and due to the increased volume.

In the case of crosslaminates it is well known that a weak bonding between the plies, or strong spot-bonding or line-bonding, gives very improved tear propagation resistance, since it allows the tear to proceed in different directions in the different plies. Thereby the notch effect is reduced. Since a crosslaminate with both plies corrugated will be spot-bonded, it will show improved tear propagation resistance, no matter whether the wavelength is short or long, but "minifluting" makes the tear stop after a very short propagation, which of course is very advantageous in most

cases. However, the improvements in tear propagation resistance, is a result not only of the spot-bonding, but also of the fluted form of each ply, which gives the ply better possibilities of changing orientation or fibrillating during the tearing, thereby absorbing energy. This is a kind of "buffer" effect.

When laminates according to the present invention are used for textile or textile-like application there is the additional advantage that the structure with crisscrossing "miniflutes", due to a smoothing influence when the laminate is given creases, reduces the rustle, or makes the tone of rustle deeper. This adds to the impression that the laminate is a kind of textile. This feature has special importance in applications as a garment for people or animals, e.g. weatherprotective or gasprotective garments, then rustle is felt irritating and is particularly bad for military uses. It should hereby be mentioned that crosslaminates according to the inventor`s earlier patents, with a barrier layer included, has found military application in several countries for gasprotective garments, but due to the rustle did not stand against competition. It is believed that this problem will be fully solved by use of the present invention.

It is also found that the special structure comprising fluted, mutually spotbonded plies, with the flutes crisscrossing, provides the laminate with some "diagonal give" like that of woven fabrics, although less than in woven fabrics, and very dependent on the depth of the

flutes and of the coeefficient of elasticity (E). This property enhances the ability of the laminate to fit with objects which it covers or encases. Heat insulating properties due to the "miniflutes" also help to give the laminate a textile-like character.

The inventor of the present invention has also filed an earlier, simultanously pending International Patent Application No. PCT/EP02/07264 which has not been published on the priority date of the present patent case. The two inventions are closely related, however the product claims of the earlier application concern a laminate of which a "minifluted" ply is laminated on one or both surfaces to a non-fluted (flat) ply, or a non-fluted (flat) ply is laminated on one or both surfaces to a "minifluted" ply. Contrary to this, it should be emphasized that in the present invention two fluted plies with different direction of the flutes are directly bonded together crests to crests through a lamination layer. Thus the structure of the old invention can be considered like a multitude of fine "pipes" bonded together, while the spotbonded structure of the present invention has a more flexible but resilient character. It allows a deeper bending without causing permanent deformations, and is also the reason for the above mentioned tendency to some textile-like "diagonal give".

If two laminates according to the old invention, each consisting of one "minifluted" ply and one flat ply, are bonded together flat ply to flat ply, with the two directions of flutes perpendicular to each other, the

resultant 4-ply will not exhibit properties like those of the present invention, since the two fluted plies are not directly bonded together in a spotbonded arrangement crests to crests. Hereby the flat in-between ply works against flexibility and resilience.

In the present invention the direct bonding crests to crests through a lamination layer will normally best be effected through a lower melting surface layer on at least one of the plies, formed in a coextrusion process. However, it is also possible to use extrusion lamination, and this will not harm the above mentioned textile-like behaviours, provided the lamination layer extruded in such procedure is so thin that it does not essentially influence the "diagonal give", flexibility and resilience of the laminate.

For the sake of good order, it should be mentioned that there already have been described "minifluted" laminates in literature,. however this concerns laminates of which the fluted ply consists of a material which is not a thermoplastic film or an assembly of thermoplastic films, and apart from this the inventor has not found any disclosure of two fluted plies in criss-crossing arrangement, neither consisting of thermoplastic nor of any other material.

US-A-6139938, which has been mentioned above, has for its object a 3-ply paper laminate with a corrugated paper sheet in the middle and flat paper sheets on each side, like normal corrugated paper board, however claimed to comprise 500-600 flutes per metre corresponding to a wavelength of

1,67-2,00 mm. The stated purpose is to improve the printability.

Japanese patent publication No. 07-251004 relates to an absorbing product in which a plane thermoplastic synthetic fiber sheet is thermally bonded to a corrugated sheet mainly consisting of active carbon fibers.. The wavelength of the corrugation is 2,5-20 mm.

Japanese patent publication No. 08-299385 relates to an absorbent laminate consisting of a fluted non-woven fabric bonded on one side to a plane sheet or film, which can be a thermoplastic film. Between these two plies is nested a water-absorbing material. The wavelength is claimed to be 3-50 mm, and it is stated that there would not be sufficient space for the absorbing material if it were less. The product is for diapers and similar products.

The method of making the present corrugated laminate of two monofilm formed or multifilm formed plies is defined in claim 40. Preferably the main direction in which the flutes of one of the plies extends is generally substantially perpendicular to the main direction in which the flutes of the other ply extends. (As it will appear from explanations below, the flutes are not always strictly rectilinear, and therefore the expression "main direction" is used). Preferably one of the flute directions essentially coincide with the machine direction of the lamination..

Thus the waved flute structure in one of the plies can be established essentially in the machine direction under a

generally transverse orientation process by taking the ply before lamination through a set of driven mutually intermeshing grooved rollers, whereby the grooves on the rollers are circular or helical and form an angle of at least 60° with the roller axis.

In this procedure the ply may be passed directly from its exit from one of the grooved stretching rollers which form its waving to the grooved lamination roller, while these two grooved rollers are in close proximity to each other and have the same pitch when measured at each ones operational temperature, and are mutually adjusted in the axial direction. A preferable modification of this routing, namely the introduction of "attenuated zones", is mentioned below.

In another procedure the waved structure in one of the plies can be established essentially perpendicularly to the machine direction by means of rollers in which the grooves are essentially parallel with the roller axis, as normal when making corrugated paper board. The two procedures are conveniently combined, so that before the lamination one ply is supplied with essentially longitudinal, and the other ply is supplied with essentially transverse flutes, and the lamination rollers are supplied with grooves, one with the grooves essentially in the machine direction, the other with its grooves essentially perpendicular to this, and the procedure is adapted so that the preformed generally longitudinal flutes will fit into the generally longitudinal grooves in one lamination roller, while the preformed

transverse flutes will fit into the transverse grooves in the other lamination roller. One of the lamination rollers should normally be a rubber roller. After the lamination the flutes in one or each ply can be made deeper by shrinkage of the other ply in the appropriate direction. This of course depends on orientation in at least one of the plies generally in the same direction as the direction of its flutes.

In a simplified procedure, which however generally makes the flutes in one of the plies more shallow, only one ply is supplied with flutes prior to the lamination. Both lamination rollers have grooves, one roller made so that the preformed flutes in one ply will fit into its grooves, and the other made so that its grooves are generally perpendicular to this direction.

Thus the laminate becomes spotbonded, and when the fluted ply subsequently is caused to shrink along the direction of its flutes (which depends on the ply having orientation in this direction) the flat ply will buckle up, forming flutes generally perpendicular to the preformed flutes, but as mentioned above usually this will be relatively shallow flutes. While the angle between the flutes in ply A and the flutes in ply B should be generally about 30° or more, it is better to make it generally about 60° or more, and usually best to make it generally about 90°.

Suitable dimensions in the laminate and divisions on the laminating rollers are stated in the product claims 3 to 6 and in method claim 45. Cross sectional dimensions are measured on micrographs.

With reference to figures 2 and 3, the lengths mentioned in claim 4 are distances from x to z, one following the curved route through the middle of A, the other the direct, lineary route.

For textile-like applications the wavelength should preferably be as low as practically possible in both plies, having hereby also regard to the economy, this means

generally about 1-1,5 mm, while for applications in stiff products like small boxes or selfstanding pouches, it should preferably be similarly low on the side which is the outside in the final product, and which possibly must be printed, but should preferably be higher on the side which is the inside in the final product. When the wavelength is about 1 mm, the quality of print can be reasonably good.

The flutes should normally consist of material which is orientable at room temperature and then suitable polymers are polyolefins. However, there are cases in which there is no special advantage in such properties, thus e.g. polystyrene will be suitable for stiff sheet material applicable for conversion to small boxes or selfstanding pouches if there is little need for high strength.

At least one of the plies may comprise a barrier film, e.g. for protection against oxygen or - as already mentioned - against harmful substances, such as gaseous substances.

When flutes are formed by means of grooved rollers prior to the lamination they will become evenly formed and extend in a generally rectilinear fashion. However, when the grooves are forme entirely by shrinkage after the lamination, their shape will be determined by the pattern of grooves in the lamination roller contacting the ply which was not corrugated before the lamination. This can of course also be an even rectilinear pattern, but in order to obtain aesthetic or interesting visual effects the pattern of the flutes in this ply can be made differently. Thus although the flutes must

extend mainly along the direction which is generally perpendicular to the flute direction in the other ply, they can nevertheless be made curved or zig-zagging and/or branched by an appropriate shaping of the pattern of grooves in the lamination roller (normally a rubber roller) which this ply contacts, or they can be made differently shaped in a pattern which gives a visual effect showing a name, text, logo or similar. Such patterns in the lamination roller can be made by methods known from rubber stereography.

For the sake of completeness it should also be mentioned that waved, partly branching and partly interrupted flutes in one ply also can be formed spontanously and at random under use of a smooth lamination roller, namely when the bonding strength is suitably adjusted to allow partial delamination during shrinkage of the other ply. Such surface structure looks like naturally wrinkled skin or leather. There can also be achived interesting visual effects by making, in a suitable pattern, a part of the mentioned lamination roller smooth and a part supplied with grooves. The above mentioned marking, showing a name, text, logo or similar can for instance be made in this way.
Such interesting visual effects and/or the appearance of the laminate as textile-like, can be enhanced when at least one of the two plies has a metallic or iridescent gloss or where the two plies are given different colours.
For most applications it is highly preferable that either the thickness of each of the said plies is generally the same in bonded and unbonded zones, or at least one ply

exhibits solid-state attenuated zones, in the following referred to as the "first" such zones, extending parallel to the flute direction, each bonding zone mainly being located with such a first attenuated zone. Hereby each first attenuated zone is understood as delimited by the positions where the thickness is an average between the lowest thickness of this ply within the first attenuated zone and the ply`s widest thickness within the adjacent non-bonded zone. The method of making the fluted laminate with such first solid-state attenuated zones located as mentioned requires a strict coordination between stretching rollers and lamination rollers, and is specified in claims 43 and 48.

In this connection, an essential attenuation of a ply in the non-bonded zones, as compared to the thickness in the bonded zones, will of course have a negative influence on the resistance to bending and the resilience (but it is generally easier to make the fluted laminate so). By contrast this resistance to bending is enhanced in comparison with the situation when the thickness is even, when there are attenuated zones and each bonding zone mainly falls within one of these attenuated zones. The attenuated zones at least in one of the plies also facilitate the manufacturing process as it later shall be explained. It is noted that while attenuation by stretching in the molten state reduces the tensile strength, attenuation by stretching in solid state increases the tensile strength in the direction in which the stretching has taken place.

The first attenuated zones are shown as (6) in figs. 2 and 3. They are here shown as almost exactly coinciding with the zones of bonding in the sections shown, which are sections drawn through the bonded spots. However, they need not be coinciding like this, since the requirement only is that each bonding zone mainly is located within a first solid-state attenuated zone. Thus, the bonding zones can to some degree extend beyond the first attenuated zones, or the latter can extend beyond the former. Preferable choices of relative zone widths for the last case are specified in claim 21.

Of course such extension of the first attenuated zones into non-bonded zones will reduce the stiffness, but will normally not reduce the resilience. It may even increase this property and will add to the textile-like character. It also tends to provide the laminate with a higher tear propagation resistance and higher impact strength.

When at least one of the plies exhibits solid-state attenuated zones, the first attenuated zones of the ply are preferably attenuated to such extent that the minimum thickness in such zone is less than 75% of the maximum thickness of the ply in the non-bonded zone. Preferably less than 50% and more preferably less than 30% of that maximum thickness.

With reference to figs. 5 and 6, the first attenuated zones are formed on and at the tips of roller 8 by the transverse stretching produced by the intermeshing between this roller and roller 7. If the surface shape of roller 8 or other

process parameters are not properly adapted to the composition and state of the ply which is being stretched, this stretching may come out as a twin zone with unstretched or less stretched material between the stretched tracks. In such cases each first attenuated zone should, in the understanding of the claims be considered as comprising the total of both twin zones and the unstretched or less stretched track between them.

In addition to first attenuated zones in at least one of the two plies, such ply can be supplied with a further set of solid-state attenuated zones, hereafter referred to as the second such zones. They are located between each pair of adjacent first attenuated zones, are narrower than said first attenuated zones and are placed on the non-bonded crests of the respectively ply. This is illustrated in fig. 3. The method of manufacturing these second attenuated zones is specified in claim 44.

The second attenuated zones act as "hinges", and if they are made narrow and deep enough they improve the stiffness, since the cross-section of A becomes zig-zagging instead of smoothly waved (as described further in connection with fig. 3) and A and B thereby get triangular cross sections. The second attenuated zones can also in some cases facilitate the manufacturing process, as it is explained below.

In addition to the improvements in stiffness and resilience caused by the first and second attenuated zones (improvements seen in relation to the average thickness of A) each set of zones also in many cases improves the

resistance against shock actions, such as impact strength, shock-puncture resistance and shock-tear propagation resistance. This is because there is started a stretching in the ply transverse to the flutes, and this stretching often has a tendency to progress under shock actions, whereby the first and second attenuated zones can act as shock-absorbers.

The proper location of the "first attenuated zones" relative to the zones of bonding is established by suitably coordinating the grooved stretching rollers which make the "first attenuated zones", with the grooved rollers for lamination.

The "second sttenuated zones" which have been described above, can be formed by stretching between a further set of grooved rollers suitably coordinated with the grooved rollers which produce the first attenuated zones.

The advantages of the first and second attenuated zones in terms of product properties have already been explained. An advantage processwise is that the first attenuated lines allow increases of velocity and therefore improved economy, since the zones in ply A which are going to be bonded, have been made thinner and therefore require less heating time during the application of heat prior to the bonding. Furthermore the first attenuated zones and in particular the combination of first and second attenuated zones can be of great help for the process by acting as "hinges" in ply A. In the type of apparatus in which the grooved roller for lamination has grooves which are generally parallel with its

axis, these "hinges" make it possible to direct even relatively heavy A-ply into fine grooves. In the type of apparatus in which the grooves are circular or helical, but in any case approximately perpendicular to the roller axis, the "hinges" help to keep ply A "in track" during its passage from grooved roller to grooved roller, in other works the "hinges" help to coordinate the action of the grooved lamination roller with the action of the preceding set or sets of grooved rollers which form the flute under a simultaneous transverse stretching.

Preferable ways of coordinating and carrying out the different grooved roller operations are further specified in claims 51 to 55.

The films used for each of the plies are usually but not always (as it appears from the foregoing) prior to forming of the waved configurations and prior to making of the first and second attenuated zones (if such zones are made), supplied with orientation in one or both directions, the resultant main direction of orientation in each ply being generally in the direction which is selected to become the direction of fluting. This can be by means of a strong melt orientation, or preferably, alternatively or additonally by known stretching procedures carried out in the solid state. If the process is adapted to make the flutes generally parallel with the machine direction, this will be a generally longitudinal orientation process, which is simple, and if the process is adapted to make the flutes generally perpendicular to the machine direction, it will be a

generally transverse orientation process which is much more complicated to establish and usually requires expensive machinery.

More precisely expressed one or both plies will normally, outside their first attenuated zones if such zones are present, be molecularly oriented mainly in a direction parallel to the direction of their flutes or in a direction close to the latter. (The main direction of orientation can be found by shrinkage tests).

Thus, in the judgement of the inventor, the product of the invention in its most important embodiment is a crosslaminate with the main direction of orientation in each ply generally coinciding with the direction of its flutes.

If one or both plies are composed of several films, the said orientation mainly in a direction parallel to the direction of the flutes, should be understood as the resultant of the different monoaxial or biaxial orientations in the said films, which may be differently directed.

As an example, ply A may consist of a single coextruded film with orientation and flutes extending in the machine direction, while ply B, the flutes of which extend perpendicular to the machine direction in itself is a crosslaminate of two films, each oriented at an angle substantially higher than 45° (e.g. one +60° and the other -60°) to the machine direction. Each of these obliquely oriented films can be produced by helical cutting of a longitudinally oriented tubular films as described e.g. in EP-A-0624126 and GB-A-1526722, both mentioned above, and disclosed in more detail in EP-A-0426702. (The latter also

discloses a method of obtaining a uniaxial or strongly unbalanced melt orientation which is perpendicular to the machine direction, namely by twisting of a tubular film coming out of the extrusion die followed by helical cutting under the calculated angle.)

The ply which in itself is a crosslaminate, should preferably be made as a laminate prior to the flute producing process step, preferably a lamination through lower melting, coextruded surface layers.

Similarly ply A, instead of being a single coextruded longitudinally oriented film, may in itself be a crosslaminate of two films, each oriented at an angle substantially lower than 45° (e.g. one +30° and the other -30°) to the machine direction, and each produced by helical cutting. These two films may after their joining be further stretched in the direction which then is machine direction. Of course this is more complicated than simply using one coextruded longitudinally oriented film as ply A, but it can provide essential improvements in tear and puncture strength.

While the use of the present invention mainly is for strength film, this needs not always mean high strength in all directions. By contrast there are cases, e.g. in in construction of bags, where the focus should be on the strength in one direction, combined with a certain puncture and tear propagation resistance. As an example a conventional industrial bag of film thickness 0,160 mm made from a blend of 90% LDPE and 10% LLDPE will typically in its

longitudinal direction show a yield force of 20 $Ncm^{-1}$, i.e. a yield tension of 12,5 MPa and in its transverse direction shows a yield force of 16 $Ncm^{-1}$, i.e. a yield tension of 10,0 MPa.

Commercially available crosslaminated film material in average thickness 0,086 mm for heatsealable bags developed by the inventor and manufactured in accordance with the above mentioned EP-A-0624126 shows in its strongest direction a yield force of 20 $Ncm^{-1}$, i.e. 23 MPa, and in its weakest direction a yield force of 17 $Ncm^{-1}$, i.e. a yield tension of 20 MPa.

Since the invention in principle relates to flexible laminates for uses where relatively high strength is required, although the emphasis of the invention is on stiffness, feel and appearance, the yield tension of the laminate in its strongest direction should normally be no less than 15 MPa, preferably no less than 25 MPa. Correspondingly the ultimate tensile tension is conveniently about twice the said indicated values, or more. Here the cross section in $mm^2$ is based on the solid material only, not including the air spaces, and it is an average, considering that ply A may have attenuated zones.

The yield tensions mentioned here refer to tensile testing at an extension velocity of 500% per minute. They are established from strain/stress graphs. These graphs will begin linear accordingly to Hook`s law, but will normally soon deviate from linearity although the deformation still is elastic. In principle the yield tension should be the

tension at which the deformation becomes permanent, but this critical value, which is velocity dependent, is practically impossible to determine. The way yield tension normally is determined in practice, and also considered determined in connection with the present claims is the following:

In case the tension reaches a relative maximum, then remains constant or decreases under continued elongation, later to increase again until break occurs, the relative maximum of the tension is considered to be the yield tension. The sample may also break at this point, and then the yield tension equals the ultimate tensile tension. If however the tension continues to increase with the continued elongation, but with much lower increases in tension per percentage elongation, then the strain/stress curve after yield, and after it practically has become a straight line, is extrapolated backward to intersect with the line which represents the Hook's-Law-part of the stretching. The tension at the intersection between the two lines is the defined yield tension.

An embodiment of the invention is characterised in that at least one of the plies by the choice of polymer material or by an incorporated filler or by orientation, within the non-bonded zones exhibits an average yield tension parallel to the direction of fluting, which when it is determined as explained above, if no less than 30 $Nmm^{-2}$ (cross section of ply A alone), preferably no less than 50 $Nmm^{-2}$ and still more preferably no less than 75 $Nmm^{-2}$.

An example of a laminate construction which can be simpler

in manufacture than a crosslaminate, and still for many purposes can be considered a high strength laminate, is a laminate according to the invention in which one ply, say A, is uniaxially or biaxially oriented in very unbalanced manner with the main direction of orientation generally coinciding with its direction of flutes (this may mainly be the machine direction or mainly be perpendicular to the latter) while ply B, without exhibiting a main direction of orientation generally perpendicular to that of A, is biaxially oriented so that the orientation outside its first attenuated zones (if such zones are present) anayway is higher than A`s average orientation in the same direction outside its first attenuated zones (if such zones are present). Ply B may simply be a strongly blown film.

In some cases there is advantage of having different elastical properties in different directions, and in such cases the materials may be choosen so that B gets a lower coeefficient of elasticity than A, both as measured in the direction perpendicular to the flute direction of A.

In an interesting special case, e.g. for bags which shall withstand drop from big heights, the choise of material for B and the depth of A`s fluting is such that by stretching of the laminate perpendicular to the direction of A`s fluting up to the point where A`s waving has disappeared, B still has not undergone any significant plastic deformation, preferably B is selected as a thermoplastic elastomer. A is also in this case oriented in a direction parallel to the flutes or close hereto (orientation in first attenuated

zones is disregarded).

As it appears especially from the introduction, the present invention is expected to be applicable in several very different fields of uses, also uses where stiffness is the most important requirement, for example the use for stand-up pouches. Claim 29 specifies the stiffness selected for such applications.

Some or all of the flute in one or both plies may be flattened at intervals, and then preferably bonded across each ones entire width at the flattened locations to make the two arrays of flutes form closed pockets. The flattened portions of a number of mutually adjacent flutes or of all flutes should usually be in array. The flattening can serve as preforming of a sharp bending in the final product, e.g. to help making a stand-up pouch, or making the bent edges of a tarpaulin. The closed pockets may also be made for purposes of "the encapsulation/canalization aspect" of the present invention, which now shall be described.

"The encapsulation/canalization aspect" comprises a number of embodiments which for different practical purposes utilize the interior cavities in the laminate, optionally in combination with suitable perforations, either to canalize a flow of liquid or air, or to encapsulate filling material in particulate, fibrous, filament or liquid form. The latter may e.g. be a preservative for goods packed in the flexible laminate. These different embodiments and some of their applications appear from product claims 30 to 38 and methods of making these products will appear from claims 58 to 64.

The embodiment of the present invention in which the fine canals or "pockets" are used to "bury" preservatives, have obvious advantages over the usual method of blending such agents with the polymers to be extruded into film form. One advantage is that the concentration of the preservative can be much higher, another that the preservative needs not be able to withstand the temperature of extrusion. The preservative may reach the object to be preserved by migration alone, or if the agent is solid it may gradually evaporate and diffuse through sufficiently fine perforations or pores.

It is also customary to contain preservative agents in small bags which are placed inside a package. Compared to this method of protection, the present invention has the advantage that the preservative agent can be distributed almost homogeneously over the full area of the packing material.

The filter material stated in claim 33 has many potential uses, e.g. as a geotextile (claim 38) but also for instance for water treatment in the chemical industry and in gas face masks.

The laminate of claim 34, which makes use of the capilary effects within the channels formed by the flutes, is an improvement over microporous film for similar purposes, since the balance between the water stopping and air allowing effects can be optimized. The uses are especially as backsheet e.g. on diapers, and for encasement of buildings.

The special way of making the perforations by melting, as claimed in claim 62, is simple and reliable to practise since the crests on the two surfaces of the laminate are protruding so that the hot roller parts safely can "burn" holes in one ply without harming the other ply. It is also a fast method. As specified in claim 63 the molten material can be dragged to form the nap claimed in claim 35. This can e.g. give a napkin a textilish feel.

The flutes of the laminate can also be used to give bags antislip properties. When filled bags are placed in a stack, they are mainly arranged so that each bag has its direction of length perpendicular to the length of the bags immediately under it. To fit with this stacking arrangement, bags made from the laminate of the invention can with advantage be constructed so that the flutes on one of its two major surfaces are generally perpendicular to those on the other major surface.

The invention shall now be explained in further detail with reference to the drawings.

Fig. 1 is a perspective view of the laminate of the invention, showing the two plies A and B, each supplied with flutes, with the directions of the flutes in the two plies crossing each other, here as it normally will be the case, perpendicular to each other. A part of ply A is removed in

order better to show the structure. The two plies are joined by spotwelding within the areas (1) shown by interrupted lines.

Figs. 2 and 3 are cross sections representing two different structures of ply A. The section is made through a crest of B, which spotwise is bonded to crests of A, and therefore the corrugated structure of B does not appear from these figures.

Fig. 4 is a principal sketch representing the steps from formation of the miniflutes in A to lamination of A with B in the manufacture of the product shown in fig. 2, the different steps being represented by the cross sections of A and B and by the cross sections of the surfaces of the rollers (cross-sections through the axis of the rollers).

Fig. 5 is a sketch of the machine line corresponding to fig. 4. The formation of flutes in B does here take place entirely by shrinkage of A after the lamination.

Fig. 6 is an enlarged detail of fig. 1 to illustrate how these plies themselves can be laminates of films, and how these films can be multilayered as made by coextrusion, this being done to facilitate bonding and lamination.

Fig. 7, 8 and 9 represent sections parallel to the flutes in ply A through the middle of a non-bonded zone in this ply, and through the bonded crests in ply B (therefore corrugations on B cannot be seen) showing applications of the invention in which the channels or pockets formed

between ply A and ply B are used as mini-containers or to canalize a flow of air or water, namely in fig. 7 as mini-containers for a protective agent, in fig. 8 for filtration and in fig. 9 for weather protection.

Fig. 10 shows a modification of the lamination station of fig. 8 in which there are added filling devices to fill particulate material into the flutes before the lamination, and added sealing equipment to form transverse seals after the lamination, therby making closed pockets which serve as "mini-containers" for the particulate material.

Fig. 11 is a flow-sheet showing a process for producing "first" and "second" attenuated zones (as these expressions have been defined), in the transversely oriented B, make transverse flutes, and laminate B with A. The latter has preformed flutes made as shown in figs. 4 and 5.

Fig. 12 shows a detail of a grooved lamination roller for formation of transverse fluting, air jets being used to direct the ply into the grooves and vacuum being used to retain it there.

With reference to figs. 2 and 3 it should be mentioned for the sake of clarity, that the wavelength referred to in the foregoing and in the claims, is the straight linear distance from x to z. This distance is about 5 mm or lower, and as it appears from the example, the inventor has been able to make it as small as 0,8 mm, which however needs not be the ultimate lower limit obtainable and useful. It is noted that US-A-5441691 (Dobrin et al.) makes embossed film (not heat-

bonded laminates) having a generally circular shape of the bosses, with a spacing from centre to centre which can be still finer than these 0,8 mm, however the bosses of this patent are drawn much thinner than the main body of the film.

In fig. 1 the thickness of each ply is shown generally constant across the ply. In case of transverse fluting this can be achieved by the process shown in fig. 12 (without prior formation of attenuated zones) however there is a limit, which is of practical importance, of how fine the wavelength can bee, seen in relation to the thickness of the ply.

In case the flutes are made parallel with the machine direction, the formation of the flutes and the lamination is preferably carried out generally as shown in figs. 4 and 5. This means there will always be a transverse stretching between intermeshing grooved rollers, and the degree of fluting will correspond to the degree of stretching. When film is stretched between very fine grooved rollers, there will be a strong tendency to localize the stretching entirely or predominantly on and near to the tips of the grooves. This can be avoided, but with difficulty, by using film which in a preceding process to some extent has been transversely stretched, and feeding the film unto the roller at a temperature which is higher than the temperature of the roller.

However, in the laminate structures shown in figs. 2 and 3 the differences of thickness resulting from grooved roller

stretching has been utilized in a way which generally is an advantage for the properties of the product. By the exact registration between the grooved rollers for stretching, the grooved roller for lamination and a grooved transfer roller therebetween, it is arranged that each bonding zone mainly falls within an attenuated zone. As it appears from fig. 3 there can be two sets of attenuated zones for each zone of bonding, namely a series (6) of relatively wider ones ("the first attenuated zones") within which the bonding zone fall, and a set of shorter ones (101), the latter referred to as the "second attenuated zones".

By attenuating ply A at the basis where it is bonded to ply B, the thickness of A is minimized at the location where its contribution to stiffness in any case is insignificant. By introducing the narrow "second attenuated zones" which act as "hinges", the cross-section becomes almost triangular as shown in fig. 3. This means that the stiffness is further improved. In many cases, these attenuated zones also introduce a tendency in the material to stretch rather than rupture under impact actions. To clarify the concepts, each first attenuated zone (6) is per definition delimited by the locations (102) where the thickness of ply A as indicated by arrows is the average between the smallest thickness in this zone and the highest thickness in the adjacent non-bonded zone.

Structures with "first attenuated zones" as shown in figs. 2 and 3 and structures with both "first and second attenuated zones", as shown in fig. 3 can also be produced with

machinery which make transverse fluting. This shall be described later.

In fig. 6 both plies A and B are in themselves laminates, for instance crosslaminates, and each film from which the plies are produced is coextruded. Therefore A and B are each formed by a lamination process (the "pre-laminaton") prior to the lamination of A to B. Layer (1a) is the main layer in each of the two coex films which make A, and layer (2) is the main layer in the two coex films which make B. Layers (1a) and (2) can e.g. consist of high density poyethylene (preferably HMWHDPE) or iso- or syndio-tactic polypropylene (PP) of blends of one of these polymers with a more flexible polymer, for instance, for HMWHDPE, LLDPE. If stiffness is the most preferred property of the minifluted laminate, plain HMWHDPE or plain PP may be choosen, but if tear and puncture properties play a more important role and/or superior heatseal properties are essential, the mentioned blends may be more suited.

Layers (3) are coextruded surface layers with the function to improve the heatseal properties of the finished laminate and/or modify its frictional properties. Layers (4) are coextruded surface layers ("lamination layers") with the two functions: a) to facilitate the pre-lamination and b) to control the bonding strength (in crosslaminates the bonding should not bee too strong, otherwise the tear propagation strength suffers).

Similarly, layers (5) are coextruded surface layers to facilitate the lamination of the entire A to the entire B

and control the strength of the bonding between A and B.

With reference to fig. 4 and fig. 5 the structure shown in fig. 2 can be formed by passing film (A) first over the grooved pre-heating roller (6a) which heats it mainly along the lines which shall become attenuated, then over the grooved stretching rollers (7) and (8), further over grooved transfer and flute-stabilizing roller (9), and finally over grooved lamination roller (10) and its rubbercoated counter-roller (11) which is supplied with axial grooves, while film B under low tension is passed over the smooth rollers (12) and (11). The laminate is taken off from lamination roller (10) over smooth roller (13). The grooves of all of the above mentioned grooved rollers, except the rubber roller, are circular so that the flutes of A are formed in the machine direction. These rollers are all temperature controlled rollers, rollers (9), (10), (11) and (12) being controlled at the lamination temperature, rollers (6a), (8) and (13) at a somewhat lower temperature and roller (7) at a temperature about 20 or 30°C. (There can be further rollers for preheating of B). By choise of suitable, coextruded surface layers - see (5) in fig. 6 - the lamination temperature is kept far below the melting range of the main layers in (A) and (B). The temperature of the zones (6) in (A) during the transverse stretching between rollers (7) and (8) is preferably still lower, e.g. in the range of about 50-70°C, and the rest of (A) much lower, e.g. around room temperature, as it also appears from the mentioned roller temperatures. If the main layers in (A) and (B) consist of

plain HDPE or blends of HDPE and LLDPE, the lamination temperature is preferably choosen between 80 and 110°C, and the coextruded lamination layers, which can consist of a suitable plain or blended copolymer of ethylene, are choosen to produce lamination at this temperature.

Ply A is longitudinally oriented prior to the processes shown in figs. 4 and 5, under conditions which gives it a tendency to shrink, e.g. 10-25% when heated to the lamination temperature. The formation of flutes in B is based on such shrinkage of A.

Ply B is transversely oriented prior to these processes, therefore also has a tendency to shrink. This shrinkage will ruin the process if not properly dealt with. In the drawing it is done by means of grooved rollers 14 a and b which give B a pleating sufficient to compensate for the shrinkage and exactly adjusted for this. This means that on the hot roller 12, B shrinks evenly allover its width in a degree which just is enough to eliminate the pleats. These grooved rollers have a rather big pitch (see example 1), are set up to pleat without transverse stretching, work at room temperature, and are iddle rollers which almost do not increase the tension in the film.
The crests on roller (8) have very small radius of curvature, e.g. about 0,07 mm or an similarly narrow "land". The crests on roller (6a) which have the function to preheat, may, depending on the film, be similar or somewhat rounder or with a slightly wider land. The crests on rollers

(7) and (9) have a higher radius of curvature to avoid transverse stretching on these crests. Suitable values for the sizes of the grooves are mentioned below in the example.

The different temperatures on the different grooved rollers cause different thermal expansions, compared to a state where all have room temperature, and this must be taken into consideration when the grooved rollers are constructed, since they must fit exactly to each other during operation. (10°C heating of a 10 cm long steel roller segment causes about 0,012 mm expansion of this segment). Reference is again made to values in the example.

Rollers (6a), (7), (8), (9), (10) and (11) are driven, the latter through (10), while rollers (12), (13), (14a) and (14b) may be idling.
As it will be understood, the attenuation of A in the zones (6) takes place almost entirely by the transverse orientation at a temperature essentially below the melting range of the main body of A. This attenuation therefore does not cause any significant weakening of A's transverse strength, contrarily it will often cause an increase of this strength. After the transverse stretching on the crests of roller (8) the width of the "first attenuated zones" (6) should preferably not exceed (as a rule of the thumb) half the wavelength, but the degree of stretching should normally be as high as practically obtainable, while the degree of transverse stretching between the "first attenuated zones" normally should be as low as practically obtainable, with

the intended result that ply A in the unbonded zones becomes as thick as the choosen square metre weight of A allows and the flutes become as high as possible.

The use of longitudinally oriented A-ply will impart a tendency in A to "neck down" and form thin longitudinal lines when A is transversely stretched on roller 8. Therefore, longitudinally oriented A-ply will enhance the possibilities of getting a sharp distinction between strongly attenuated zones (6) and non-attenuated ply A between these zones.

The line of rollers (6a) to (10), which ply A follows, rotate at equal circumferential velocity. Thus the heating and A`s longitudinal orientation will have given A a rather high longitudinal tension when it laminates with B in the nip between the circularly grooved hot lamination roller (10) and the rubber coated axially grooved, hot lamination roller (11). Since roller (13) is idling and the laminate is taken off from this roller under a low tension, ply A will gradually shrink when it has passed this nip where lamination takes place and while it still is on the hot lamination roller (10). Roller (13) is close to roller (10) without contacting it, thereby each fine flute in A will remain in its groove during the shrinkage, and the latter will take place in a well ordered manner, producing regular flutes in B.

Roller (13) also serves to counteract or eliminate a tendency in the final laminate to curl around a transverse direction. This tendency is mainly due to tensions created

by the shrinkage of ply A and ply B`s resistance to this. While the laminate follows roller (13), which as mentioned is a hot roller, it is bent oppositely, thereby counteracting the effect of "differential shrinkage". Furthermore the surface of (13) may be supplied with a very shallow pattern of circular grooves imparting the laminate with coarse and very shallow, longitudinally extending waves, which completely can eliminate the tendency to curling. These waves can have a depth of e.g. 0,5-5 mm and a wavelength about 10-20 times the depth. The laminate is air cooled while it leaves roller (13) under a low tension.

With certain modification the line shown in figs. 7 and 8 can also be used to make the laminate of fig. 3, which has "second attenuated zones". For this purpose roller (6a) should have the same profile and the same low temperature as roller (7), and it should be preceded by and in slight engagement with a roller with the same surface profile as roller (8), which roller should have the same higher temperature as roller (8).

In fig. 7 which as mentioned shows a longitudinal section through a flute in ply A, the both plies have been flattened and sealed to each other at intervals (103) to form pockets or "mini-containers", and these mini-containers have been filled with a particulate substance (104) which has a purpose for the use of the laminate, e.g. for protection of material packed or wrapped up in the latter. As one among many options it may be an oxygen scavenger. To enhance the action of the substance the flutes may be supplied with fine

perforations on the side towards the packed product. The substance may also e.g. be a fire retardant material such as $CaCl_2$ with crystal water, or just fine sand to increase the bulk density of the laminate.

Fig. 10 which shall be described below, shows how the particulate substance can be fed into the flutes of ply A prior to its lamination with ply B, and how the flutes can be closed to pockets by transverse sealing after the lamination, without any essential contamination of these transverse seals.

A laminate between a fluted thermoplastic film and a non-fluted thermoplastic film with a filling material between is known from Japanese Patent publication No. 07-276547 (Hino Masahito). However, in this case the filling material is a continous porous sheet (for absorbtion) which extends from flute to flute without interruptions, so that there is no direct bonding between the flute and the non-fluted films. One of the thermoplastic films is first directly extruded unto this porous (e.g. fiberformed) sheet, then the two together are given a fluted shape between gear rollers while the thermoplastic film still is molten, and finally a second thermoplastic film is extruded directly unto this fluted assembly to join with the porous sheet. Hereby the bonding necessarily must be very weak, and the mechanical characteristics must be completely different from those of the present product. The wavelength of the fluting is not indicated.

In the technical filter material for liquid or gas flows

shown in fig. 8 there is inserted a strand or yarn into each flute of A - in connection with the description of fig. 10 it shall be explained how that can be done - and both plies are supplied with rows of perforations, (106) in ply A and (107) in ply B. These rows are mutually displaced as shown so that the liquid or gas passing from one surface of the laminate to the other, is forced to follow a channel over a distance corresponding to the displacement. The fitting between the yarn and the channel may be improved by shrinkage of A and/or B after the lamination process.

The pocket structure shown in fig. 7 can also be used for filtration purposes if ply A and ply B are supplied with mutually displaced holes. Then the particulate substance (104) can e.g. consist of active charcoal, or an ion-exchange resin, or for simple filtration purposes fine sand. Also in this case a tightening of the passage by means of shrinkage can be advantageous or may even be needed.

Practical examples of the use of such filter materials are for air filtration systems including absorbtion of poisonous substances, and ion-exchange processes. In both cases the laminate can have the form of a long web which is slowly advanced transversely to flow which passes through it.

Another practical use is as a substitute of geotextiles e.g. for road constructions. Such textiles must allow water to penetrate but hold back even fine particles. The present laminate, e.g. filled with fine sand in the pockets, is

suited for this use.

For such filtration purposes, high puncture strength will often be needed, and the laminate then preferably comprises oriented, crosslaminated films.

The weather protective laminate shown in fig. 9, e.g. for raincoats, also has a pocket structure, whereby ply A is heatsealed to ply B by transverse seals at locations (103), but there is no particulate substance in the pockets. Like the laminate for filtration, each line of pockets is supplied with perforations in a displaced system, here shown as groups of perforations (109) in A and similar groups (110) in B, and these groups are mutually displaced. In this sketch it is considered that ply A is on the side where it rains, and a person, animal or item, which the laminate shall protect, is on the ply B side. (It could be the other way round). It is also considered that the direction shown by arrow (108) is upward. Since the perforations (109) are at the bottom of the pockets, and because of the gravity force, only the bottom of the pockets may be filled with rainwater, while in principle no water will reach the perforations (110). On the other hand there is free passage of air and transpiration between the hole groups (109) and (110).

The modification of the fig. 5 machine-line shown in fig. 10, is adapted to fill a particulate substance (104) into the channels formed between A and B. The filling is here shown very schematically. The powder (104) is taken from a hopper (111) and is administered by means of an adjustable

vibrator (not shown). It falls into the fluted ply A at the upper side of the grooved lamination roller (10). At regular time intervals hopper (111) is filled up with the powder (104). The means for this are not shown. Other conventional systems for administering the powder (104) onto ply A on roller (10) may of course be chosen.
Roller (10) vibrates (means not shown) so that the powder is moved from the higher zones, i.e. those which become bonded zones when A meets B in the nip between (10) and (11), into the lower zones, which become the "channels".

Having left the laminating rollers (10), (11) and roller (13), the A+B-laminate with powder (104) in the channels moves towards the cog-roller (113) - its surface is shown in a detailed part-drawing - and its rubber coated counterroller (114) which together flatten and close the channels by making transverse seals. Roller (113) is vibrated in order to move powder away from the channel-parts which become flattened and sealed.

Both rollers (113) and (114) are heated to a temperature needed for the sealing, and since the laminate while entering these rollers still is at a temperature suitable for heatsealing due to the previous temperatures, this second heatseal process needs not cause a deceleration of the entire process.
For producing the product of fig. 8, rollers (113) and (114) can be omitted or taken out of function, and instead of administering powder into ply A, there can at the same place

be laid a yarn into each flute. Each yarn is taken from a separate reel.

At some stage after rollers (10)/(11), ply B may be subjected to transverse shrinkage. It may be necessary to hold the laminate at the edges while B shrinks. This may be done by means of an ordinary tenterframe, but the latter should be set up to work "inversely" so that the width gradually is reduced instead of increased.

The process for making the transversely pre-fluted ply B, which appears from the flow-sheet fig. 11 is generally analogous to the process which is described in connection with figs. 4 and 5, and the profiles of the grooved rollers can also be generally similar, except that for the process of fig. 11 the grooves extend axially, while for the process of figs. 4 and 5 they are circular.

<u>Step 1:</u> Transverely oriented ply B, which was made tensionless at the lamination temperature and then again cooled, is longitudinally stretched in very narrow zones localized on the tips of a hot roller which has a profile similar to that of roller (8). The grooved counter-roller, which is cold, has a profile like that of roller (7).

<u>Step 2:</u> The warm, stretched "second attenuated zones" are cooled on a cold grooved roller which also has a profile like that of roller (7). Then to form "first attenuated zones" between the "second", ply A is longitudinally stretched between this cold roller and a warm grooved roller which also has a profile similar to that of roller (8). The

stretching is localized to the tips of this roller. Similar to the registration in printing technology, step 2 is brought in registration with step 1 under use of a device which optically detects the the stretched zones.

Step 3: The flutes are first formed in the grooves of a hot rubbercoated roller with a profile similar to that of roller (10), e.g. under use of compressed air, and are held in the grooves e.g. under use of vacuum, all as explained in connection with fig. 12 and ply B is then laminated with ply A between the crests of this grooved rubber roller and a circularly grooved steel-roller, which also is heated. Ply A has been preheated, and has already been supplied with flutes in the process shown in figs. 4 and 5.

There can be different after treatments as explained in the foregoing, in particular after-shrinkage in one or both directions.

In fig. 12, ply B which has been supplied first with the very narrow transverse "second attenuated zones" (101), and then with the somewhat wider, also transverse "first attenuated zones" (6), is directed into the grooves (115) of the heated lamination roller by means of compressed air from a row of nozzles of which one (116) is shown. By use of registration means, working on basis of optical detection of zones (6) or (101) it is arranged that the first attenuated zones (6) will cover the crests (118) of the grooved roller. The two sets of attenuated zones act as hinges so that even a quite heavy ply B may be bent and form the flutes. The

latter are held in shape in the grooves under use of vacuum applied through channels (117) from the interior of the roller. Thus ply B is moved in flute shape to the nip (not shown) between the grooved roller and the circularly grooved counter-roller, where lamination takes place. One of the two rollers, preferably that which feeds B, is rubbercoated. The vacuum in the grooves is adjusted so that ply A is held firmly when this is needed, but can be released where that is needed. There can also be a valve arrangement inside the grooved roller to eliminate the vacuum during the release.

Example 1

A 2-ply laminate of ply A and ply B with A longitudinally and B transversely fluted and oriented is manufactured on a pilot unit constructed as shown in figs. 4 and 5. Both plies consist of one coextruded, cold-stretched 0,037 mm thick film consisting of HDPE with a thin layer on one side, consisting of an ethylene copolymer having a melting range between 95-105$^{o}$C. This is used as lamination layer in the process. The cold-stretching was carried out near room temperature at a draw ratio about 3:1 and was followed by heat stabilization, all by conventional means, and while the film had flat tubular form. The tube was longitudinally cut to form ply A.

Processes for continous manufacture of transversely oriented film are well known and mentioned in the foregoing, but it would have caused practical complications for the inventor to have such film manufactured according to his specifications, and therefore short lenghts of the ply A-

film were glued together edge to edge with a pressure sensitive adhesive to form a transversely oriented web.

All of the grooved rollers have the pitch 1,1000 mm at the temperature at which they actually are used, but due to the large temperature differences during the stretching/laminating process, the thermal expansion had to be taken into consideration when these rollers were machined at 20°C, see the table below. The biggest temperature difference between the rollers, as it appears from this table, is 85°, and this corresponds to an expansion of about 0,10 mm per 10 cm roller length, while the accumulated error in the fitting between adjacent rollers from end to end of the rollers must be maintained lower than 0,15 mm to obtain the needed registration.

The table below also indicates the radius of curvature (R) or the length of a "land" on the crest of the grooved rollers as seen in the axial section in fig. 7.

| Roller No. | 6a | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|
| Crest | land | R= | land | R= | land | land |
| mm | 0,4 | 0,2 | 0,15 | 0,15 | 0,7 | 1,0 |
| Temperature °C | 70 | 20 | 70 | 105 | 105 | 105 |
| Pitch mm | 1,0993 | 1,1000 | 1,0993 | 1,0988 | 1,0988 | 2,000 |

The roller (12) for preheating and stabilization (shrinkage) of B is heated to ~~105~~ 90°C.

It is of course not practically possible to achieve such a

high accuracy in the pitch of rollers (6a) to (10) seen individually from groove to groove, but it is essential that errors in the pitch do not accumulate by more than 0,05 mm. This is best achieved when the surface parts are made from segments and accumulated errors are eliminated by fine grinding of the segment ends and/or thin shims (foils) are inserted between the segments. In the actual pilot machine the length of the grooved part of each roller surface was about 450 mm and was assembled from 3 segments. It is judged that in an industrial machine the rollers can be made in up to about 5 m length, but in that case the accuracy from end to end has to be checked with laser measurements and adjustments made as explained.

The transverse stretching, which is the basis for the flute formation in A and which forms the "first attenuated zones" - later the zones which become bases, not crests of the flutes in the laminate - takes place by the intermeshing between rollers (7) and (8) and becomes localized to a zone on and nearby the crests of roller (8). This is because roller (8) is hot and has a relatively sharp crest, while roller (7) is cold and has a much rounder crest (higher radius of curvature R). It is relevant also in this connection that ply A is uniaxially oriented in the machine direction and therefore has a high tendency to "neck-down" and form sharply delimited attenuated zones when it is transversely stretched.

The function of roller (6a) is to preheat the zones which are to be stretched on the tips of roller (8). In this

example the "land" on the crests of roller (6a) are wider than the "land" on the crests of roller (8). This has been chosen in order to counteract the pronounced tendency in the film to "neck-down", in other words, to make the limits of the "first attenuated zones" smoother. In other cases e.g. when ply A has a pronounced transverse orientation and therefore no tendency to "necking down" by transverse stretching, the "land" on the crests of roller (6a) which preheats the film, should be no wider than the "land" on the crests of roller (8).

Between rollers (6a) and (7) there is a slight but almost zero engagement to avoid wrinkles without stretching the films.

Having left the transverse stretching roller (8), ply A is taken over by transfer roller (9). This is heated in order to help the shaping of flutes in the zones which have not been stretched. At this stage the "first attenuated zones" are still deeply curved, but when (A) is taken over by the flat 0,4 mm wide crests (lands) on the grooved laminating roller (10) the "first attenuated zones" are flattened almost over their entire width except at their boundaries where the thickness gradually increases, and by means of the rubber coated counter roller, which on its surface has temperature 105$^{O}$C, this flat portion is laminated to the transversely oriented ply B.

Prior to the experimental run the axial positions of the grooved rollers are very carefully adjusted to each other, and so is the intermeshing between adjacent grooved rollers. The intermeshing between rollers (7) and (8) is set to make

the depth of the fluting 0,40 mm, as measured in microscope on a cross-section of the finished laminate.

The idling take-off roller (13) has heatinsulating surface so that the laminate still to some extent is formable on this roller. The roller surface is slightly corrugated, namely in a waving which seen in axial section has sinus form with wavelenght 10 mm and depth 1,0 mm. This eliminates the tendency to curling.

While leaving roller (13) under a low tension the laminate is aircooled. Measurements show that ply A has contracted 15% after the lamination step, and ply B has buckled up correspondently and formed flutes.

Example 2

The procedure of example 1 is repeated with the difference that the division of axial grooves on the rubbercoated lamination roller is changed from 2,0 mm to 1,0 mm. This also produces flutes in B by the shrinkage of A.

Example 3

The film produced as explained in example 1 is air-heated to 115°C while the edges parallel to ply A`s flutes are fixed between clambs, which however are set up so that they allow ply B freely to shrink. Hereby the wavelength in ply A is reduced to 0,8 mm.

Example 4

The laminate of example 1, however with the depth of the flutes in B reduced almost to zero, is converted to a small bag, and some flutes in the bottom of the latter is supplied

with perforations, one series in flutes of ply A, and another series in the flutes of ply B. In each of such ply A flutes the distance between the holes is 10 mm.

At the middle between each pair of these holes there is made a hole in the flute of ply B.

There is filled about 10 cm water into the bag, which is suspended in a set of frames which holds the bottom straightly lineary and allows the water to drop down on a table.

The water continues to drop until its surface stands 55 mm over the bottom, then it stops dropping. It can be concluded that the fine "caterpillary channels" in the laminate can withstand 55 mm water pressure due to their fineness and hydrophobic properties. It is noted that the laminate of my copending patent application mentioned in the introduction, in which ply A is fluted and ply B flat, has been found to show similar properties when the flutes are similarly fine, the perforations are similarly arranged, and the material is similarly hydrophobic.

CLAIMS

1. Laminate comprising at least a monofilm formed or multifilm formed ply (A) and another monofilm formed or multifilm formed ply (B) both mainly consisting of orientable thermoplastic polymer material,
in which A has a waved flute configuration and B on a first side is adhesively bonded in bonding zones to the crests on a first side of A, characterised in that a) B also has a waved configuration, the flute direction of B forming an angle from generally about 30° up to and including 90° to the flute direction of A and the said bonding zones being on the crests of the first side of B to produce spot bonding with the crests on the first side of A, b) the adhesive bonding is directly A to B and established through a lamination layer on A and/or B, and c) the wavelengths of the flutes in A and B are no longer than 5 mm.

2. Laminate according to claim 1, characterised in that either the thickness of each of the said plies is generally the same in bonded and unbonded zones, or at least one of the plies exhibits first solid-state-attenuated zones extending parallel to the flute direction, each bonding zone mainly being located within such a first attenuated zone whereby each first attenuated zone is understood as delimited by the positions where the thickness is an average between the lowest thickness of this ply within the first attenuated zone and the ply's widest thickness within the adjacent non-bonded zone.

3. Laminate according to claim 1 or 2 characterised in that the wavelength in each of the two plies is no more than 4 mm, preferably no more than 3 mm and still more preferably no more than 2 mm.

4. Laminate according to any of the preceding claims characterised in that in each of the two plies the average percentage which the curved length of a wave forms relative to the linear wavelength is at least 5 % and preferably at least 10 %, the curved length being understood as the length of a curve through the cross section of a full wave including the bonding zone which curve lays in the middle between the two surfaces of the ply.

5. Laminate according to claim 4, characterised in that in at least one of said plies the said average is at least 15 %.

6. Laminate according to any of the preceding claims, characterised in that the width of each bonding zone in at least one of the two plies is no less than 15%, preferably no less than 20%, and still more preferably no less than 30% of the wavelength.

7. Laminate according to any of the preceding claims, characterised in that the flutes in at least one of the two plies are evenly formed and extend in a generally rectilinear shape.

8. Laminate according to any of the preceding claims, characterised in that the flutes in at least one of the two plies while extending mainly along one direction, are curved

or zig-zagging and/or branched.

9. Laminate according to any of the preceding claims, characterised in that the flutes in at least one of the two plies while extending mainly along one direction are differently shaped in a pattern which gives a visual effect showing a name, text, logo or similar.

10. Laminate according to any of the preceding claims, characterised in that at least one of the two plies has a metallic or iridescent gloss, or the two plies have different colours.

11. Laminate according to any of the preceding claims, characterised in that the main direction in which the flutes of A extend is generally substantially perpendicular to the main direction in which the flutes of B extend.

12. Laminate according to claim 11, characterised in that one of the said two directions essentially coincide with the machine direction of the lamination.

13. Laminate according to any of the preceding claims, characterised in that A, outside its first attenuated zones if such zones are present, is molecularly oriented mainly in a direction parallel to the direction of its flutes or in a direction close to the latter as provable by shrinkage tests.

14. Laminate according to claim 13, characterised in that B also is molecularly oriented and B`s orientation outside its first attenuated zones if such zones are present is higher

than A`s average orientation in the same direction outside its first attenuated zones if such zones are present, the said two orientations being provable by shrinkage tests.

15. Laminate according to claims 13 or 14, characterised in that the yield tension in A in a direction parallel with its flutes and the yield tension in B in a direction with its flutes, both referring to the cross-section of the respective ply and determined in non-bonded narrow strips at an extension velocity of 500% $min^{-1}$, is no less than 30 $Nmm^{-2}$, preferably no less than 50 $Nmm^{-2}$ and still more preferably no less than 75 $Nmm^{-2}$.

16. Laminate according to any of the preceding claims, characterised in that B has a lower coefficient of elasticity than A, both as measured in the direction perpendicular to the flute direction of A.

17. Laminate according to claim 13, characterised in that the choice of material for B and of depth of A`s fluting is such that by stretching of the laminate perpendicular to the direction of A`s fluting up to the point where A`s waving has disappeared, B still has not undergone any significant plastic deformation, preferably B is selected as a thermoplastic elastomer.

18. Laminate according to claim 13, 14 or 15, characterised in that B, outside its first attenuated zones if such zones are present, is molecularly oriented mainly in a direction parallel to the direction of the flutes or in a

direction close to the latter as provable by shrinkage tests.

19. Laminate according to claim 13, characterised in that A is composed of several films, and the said orientation mainly in a direction parallel to the direction of the flutes, is the resultant of different monoaxial or biaxial orientations in the said films optionally mutually differently directed.

20. Laminate according to claim 18, characterised in that B is composed of several films, and the said orientation mainly in a direction parallel to the direction of the flutes, is the resultant of different monoaxial or biaxial orientations in the said films optionally mutually differently directed.

21. Laminate according to any of the preceding claims in which first attenuated zones are present at least in one of the two plies charaterised in that if such zones of attenuated ply extend in their transverse direction beyond the corresponding zones of bonding into non-bonded zones of the ply, the extensions within each non-bonded zone are limited to a total width which leaves more than half of and preferably no less than 70% of the width of the non-bonded zone as not belonging to any first attenuated zone, these widths being the distances measured along the curved surfaces.

22. Laminate according to any of the preceding claims in which first attenuated zones are present at least in one of the two plies charaterised by a second solid-state-

attenuated zone between each pair of adjacent first attenuated zones, said second attenuated zones being narrower than said first attenuated zones and located on the non-bonded crests of the respectively ply.

23. Laminate according to any of the preceding claims, in which at least one of the two plies exhibits solid-state-attenuated zones characterised in that the first attenuated zones of the ply are attenuated so that the minimum thickness in such zone is less than 75% of the maximum thickness of the ply in the non-bonded zone, preferably less than 50% and more preferably less than 30% of that maximum thickness.

24. Laminate according to any of the preceding claims, characterised in that A and B consist of material which is orientable at room temperature, preferably they mainly consist of polyolefin.

25. Laminate according to any of the preceding claims, characterised in that the spot-bonding between plies A and B is effected through a lower melting surface layer on at least one of the plies, formed in a coextrusion process.

26. Laminate according to any of the preceding claims, characterised in that at least one of the plies comprises a barrier film, e.g. for protection against oxygen or other gaseous materials.

27. Laminate according to any of the preceding claims, characterised in that at least some of the flutes in one or both plies are flattened at intervals and preferably bonded across each ones entire width at the flattened locations to

make the two arrays of flutes form closed pockets.

28. Laminate according to claim 27, characterised in that the flattened portions of a number of mutually adjacent flutes or of all flutes are in array.

29. Laminate according to any of claims 1 to 22 characterised in that by the choice of polymer material or by an incorporated filler or by orientation, the coefficient of elasticity E in at least one of the plies, measured in the unbonded zone of the ply in the direction parallel to the flute, as an average over the unbonded zone is no less than 700 MPa, and preferably no less than 1000 MPa.

30. Laminate according to any of the preceding claims, characterised in that at least some of the channels formed by the flutes in A and B, which channels may be closed to pockets, contain a filling material in particulate, fibrous, filament or liquid form.

31. Laminate according to claim 30, characterised in that said material is a preservative for goods intended to become packed in or protected by the laminate, preferably an oxygen scavenger or ethylene scavenger, a biocide, such as a fungicide or bactericide, a corrosion inhibitor or a fire extinguishing agent, optionally with micro-perforations established in the flutes to enhance the effect of said preservative.

32. Laminate according to any of the preceding claims, characterised in that both A and B are supplied with a

multitude of perforations, whereby the bonded spots do not border on any perforation, and the perforations in A are displaced from the perforations in B so as to cause gas or liquid when passing through the laminate, to run a distance through the flutes generally parallel to the main surfaces of the laminate; the channels formed by the flutes may be closed to form pockets.

33. Laminate according to claim 32, characterised in that the channels or pockets contain filling material adapted to act as a filter material by holding back suspended particles from a liquid passing through the channels or pockets or is an absorbent or ion exchanger capable of absorbing or exchanging matter dissolved in such liquid, said filler optionally being fibreformed or yarnformed.

34. Laminate according to claim 33, in which by choose of hydrophobic properties of at least the inner surfaces of the channels or pockets formed by the flutes and by selected small spacing of said channels or pockets, and choice of the distances between the mutually displaced perforations in A and B, there is achieved a desirable balance between the pressure needed to allow water through the laminate and the laminate's capability to allow air and vapor to pass therethrough.

35. Laminate according to claim 34, characterised by a nap of fibrelike filmportions protruding from the borders of the perforations at least on one surface of the laminate.

36. Laminate according to claim 34 or 35, used as a sanitary backsheet, e.g. on a diaper.

37. Laminate according to claim 34 or 35, used for encasement of buildings.

38. Laminate according to claim 33 used as a geotextile which allows water to pass but holds fine particles back, the filter material optionally being sand.

39. A bag made from the laminate according to any of the claims 1 to 32, characterised in that the flutes on one of the two major surfaces of the bag are generally perpendicular to the flutes on the other major surface of the bag.

40. Method of manufacturing a laminate of a first monofilm formed or multifilm formed ply with a second monofilm formed or multifilm formed ply both mainly consisting of orientable thermoplastic polymer material, in which the first ply has a waved flute configuration, and the second ply on a first side is adhesively bonded in bonding zones to the crests on a first side of A, in which further the waved flute structure of the first ply is formed by the use of a grooved roller, and the said bonding with the second ply is carried out under heat and pressure and also under use of a grooved roller, characterised in that a) the second ply also is given a waved configuration, whereby under use of at least one grooved roller the flute direction of the second ply is made at an angle to the flute direction of the first ply and the said bonding zones are established on the crests of the first side of the second ply to produce spot bonding with the crests on the first side of the first ply,
b) the adhesive bonding is directly first to second ply and

established through a lamination layer on at least one of these plies, and

c) the wavelenghts of the flutes in both plies are no longer than 5 mm.

41. Method according to claim 40, characterised in that the films constituting at least one of the two plies are made by coextrusion in which there is coextruded a lower melting surface layer to enable the lamination without any melting of the main body of the plies.

42. Method according to claim 40 or 41, characterised in that the two plies consist of material which is orientable at room temperature, preferably they mainly consist of polyolefin.

43. Method according to claims 40, 41 or 42 characterised in that prior to the said bonding process at least one of said plies is solid-state stretched in narrow zones to form first attenuated zones which are parallel to the selected direction of fluting in the ply, said stretching being generally perpendicular to the said direction and carried out between a set of grooved rollers both different from the grooved roller for lamination, and that the grooved roller for lamination is coordinated with the said set of grooved rollers for stretching in such a way that each zone of bonding mainly becomes located within a first attenuated zone.

44. Method according to claim 43, characterised in that

prior to or after the formation of the first attenuated zones another set of grooved rollers produces second attenuated zones which are another series of solid-state oriented narrow zones in the same ply, parallel with the first attenuated zones and narrower than the latter, while the grooved rollers which produce said second attenuated zone are coordinated with the grooved rollers which produce the first attenuated zones so that each second attenuated zone becomes located generally in the middle between two neighbouring first attenuated zones.

45. Method according to any of the claims 40 to 44, characterised in that the pitch of the grooved roller which produces the lamination on the crests is at the highest 3,0 mm, preferably no more than 2,0 mm and still more preferably no more than 1,5 mm.

46. Method according to any of the claims 40 to 45, characterised in that prior to the forming of the waved flute structure and if the methods of claims 43 or 44 are used, also prior to the formation of the attenuated zones, the film or films constituting at least one of the plies are supplied with orientation in one or both directions, the resultant main direction of orientation in such ply being essentially in the direction which is selected to become its direction of fluting.

47. Method according to any of the claims 40 to 46, characterised in that at least a part of the depth of each flute in at least one of the two plies, is carried out after the lamination by thermal shrinkage of the other ply in a

direction essentially perpendicular to the predetermined direction of such flutes.

48. Method according to claim 43, <u>characterised in that</u> a suitably distinct stripe formation of the first attenuated zone is established at least in part by giving the crests on the grooved stretching roller intended to produce the stripes a temperature which is higher than the temperature on the crests on the other grooved stretching roller and/or by giving the crests on the grooved stretching roller intended to produce the stripes a radius of curvature which is smaller than the radius of curvature of the crests on the matching grooved stretching roller.

49. Method according to any of the claims 40 to 48, <u>characterised in that</u> the waved flute structure in one of the plies is established essentially in the machine direction under a generally transverse orientation process by taking the ply before lamination through a set of driven mutually intermeshing grooved rollers, the grooves on the rollers being circular or helical and forming an angle of at least $60^{\circ}$ with the roller axis.

50. Method according to claim 49, <u>characterised in that</u> this ply is passed directly from its exit from one of the grooved stretching rollers which form its waving to the grooved lamination roller, these two grooved rollers being in close proximity to each other and having the same pitch when measured at each ones operational temperature and being mutually adjusted in the axial direction.

51. Method according to claim 49, <u>characterised in that</u> this ply is passed from its exit from one of the grooved stretching rollers which form its waving to the grooved lamination roller over one or a series of heated, grooved transfer rollers, the grooved rollers in the row starting with the grooved stretching rollers and ending with the grooved lamination roller each being in close proximity to its neighbour or neighbours, whereby each of the grooved rollers in the row has the same pitch when measured at their respective operational temperature, and being mutually adjusted in the axial direction.

52. Method according to any of the claims 40 to 48, <u>characterised in that</u> each grooved roller used to form the flutes in one of the plies and each grooved roller used to form the first attenuated zones in this ply according to claim 43 if such zones are produced, and each grooved roller used to form the second attenuated zones according to claim 44 if such zones are formed in this ply and a grooved roller which the ply follows before and during the lamination if such roller is used, are rollers in which the grooves are essentially parallel with the roller axis, and means are provided to hold the flutes of the said ply in the respective grooves during the passage from the position where the flutes are formed to the position where lamination takes place, said holding means adapted to avoid a frictional rubbing on the ply during said passage.

53. Method according to claim 52, <u>characterised in that</u> the flutes in this ply are formed by use of an air jet or

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a transverse row of airjets which directs A into the grooves on the forming roller.

54. Method according to claims 52 or 53, characterised in that if first attenuated zones are formed accordingly to claim 43 by grooved rollers acting in coordination with the grooved roller used for lamination, said coordination consists in an automatic fine regulation of the relative velocities between the rollers.

55. Method according to claim 54, characterised in that when second attenuated zones are formed according to claim 44 by grooved rollers acting in coordination with the grooved rollers used to produce the first attenuated zones, said coordination consists in an automatic fine regulation of the relative velocities between the rollers.

56. Method according to any of claims 40 to 55, characterised in that after the lamination at least some of the flutes in each ply are flattened in locations placed at intervals, preferably under heat and pressure sufficient to bond the plies to each other in said locations so that the two arrays of flutes together form closed pockets.

57. Method according to claim 56, characterised in that at least some of the flattening is carried out with bars or cogs which have their longitudinal direction arranged generally in the machine direction and/or the direction transverse to this.

58. Method according to any of claims 40 to 57,

characterised in that particulate, liquid or thread/yarnformed material is filled into some at least of the channels formed by the two arrays of flutes, this filling taking place before, prior to or during the lamination.

59. Method according to claim 58, characterised in that after filling the filled channels are closed at intervals by pressure and heat to form filled pockets.

60. Method according to claim 58 or 59, characterised in that prior to, simultaneously with or following the filling step perforations are made in the laminate at least on one side to help the filling material or part thereof dissipate into the surroundings or to allow air or liquid to pass through the filling material.

61. Method according to any of the claims 40 to 60, characterised in that there is made a multitude of perforations in the first and in the second ply, but limited to areas, where the two plies are not bonded together, and the perforations in the first ply being displaced from the perforations in the second ply to force air or liquid which passes through the laminate to run a distance along a channel.

62. Method according to any of the claims 40 to 62, characterised in that in one process step there is melted a multitude of holes in the first but not in the second ply, these holes being formed by contacting flutes of the first ply with protruding surface parts of a hot roller,

which are moved at essentially the same velocity as the laminate.

63. Method according to any of the claims 40 to 62, characterised in that in one process step there is melted a multitude of holes in the second but not in the first ply, these holes being formed by contacting flutes of the second ply with protruding surface parts of a hot roller, which are moved at essentially the same velocity as the laminate.

64. Method according to claim 62 to 63, characterised in that there is drawn a protruding nap of fibrelike film portions out from the molten surroundings of the holes by blowing air in between the laminate and the hot roller, where the laminate leaves the roller.

Fig. 1.

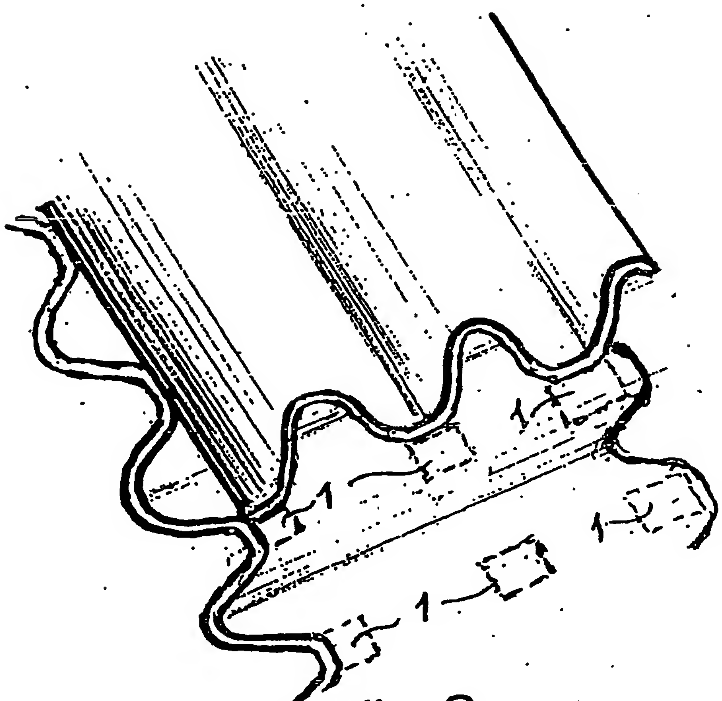



Fig.2.

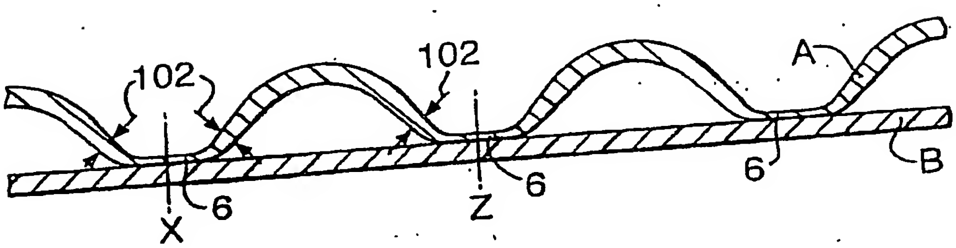
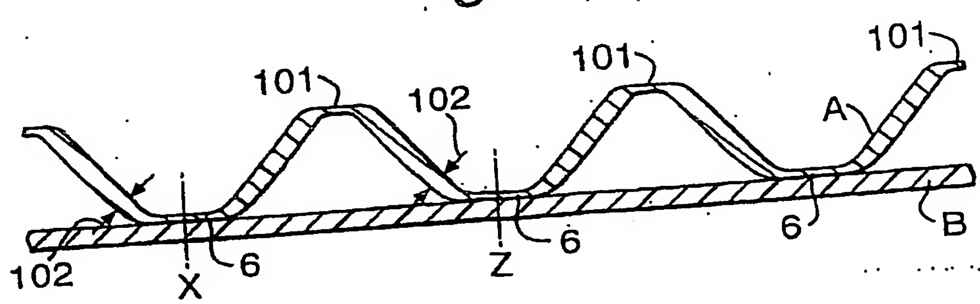



Fig.3.



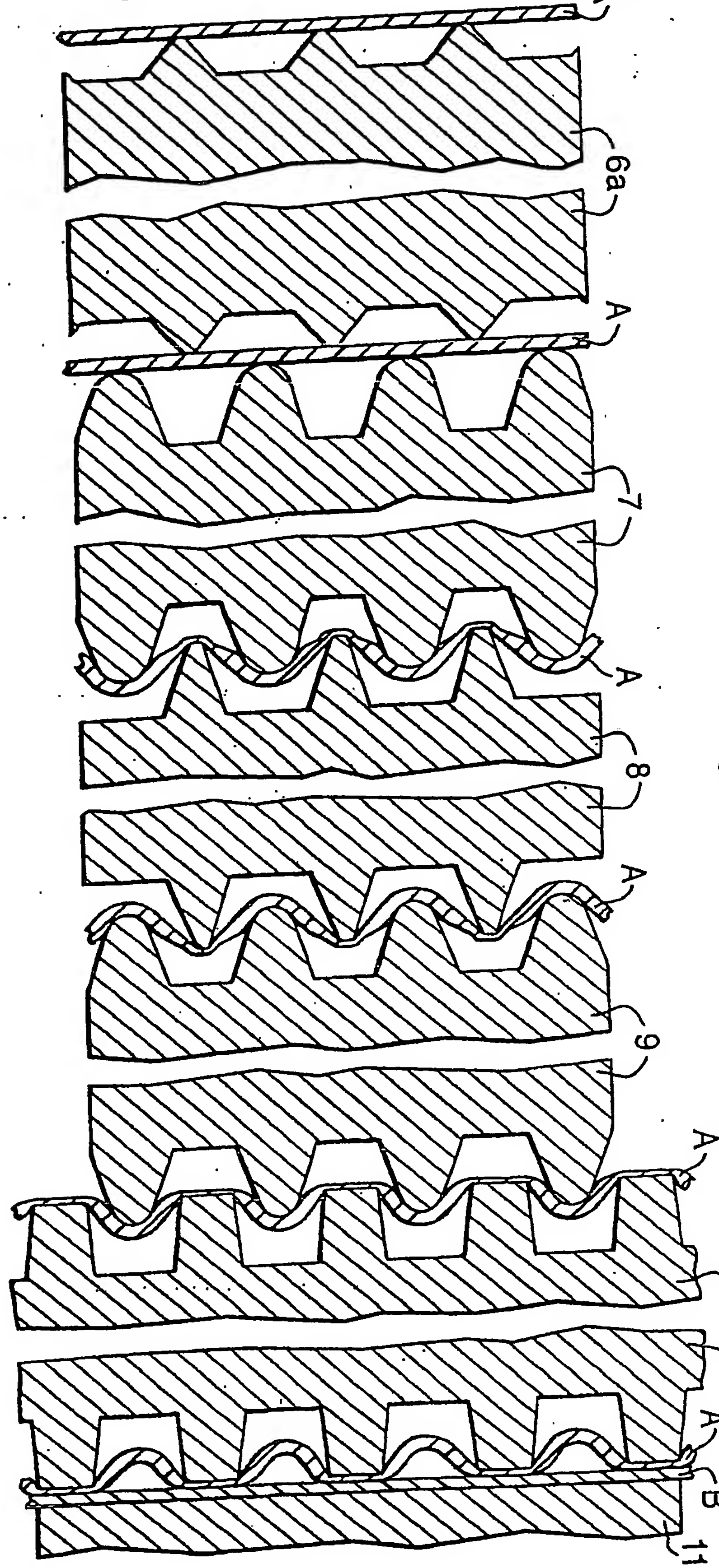



Fig.4.

Fig.5.

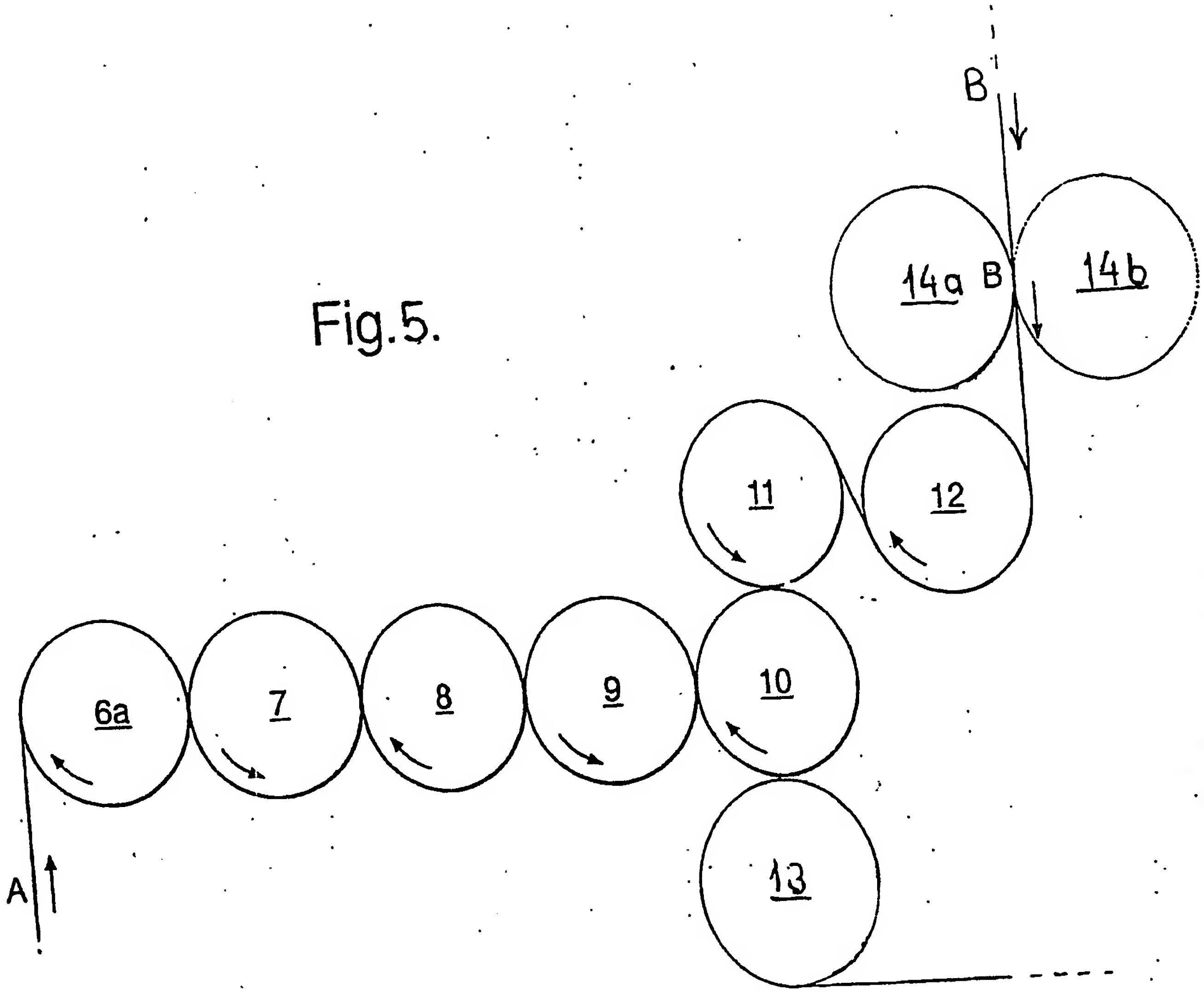



Fig.6.

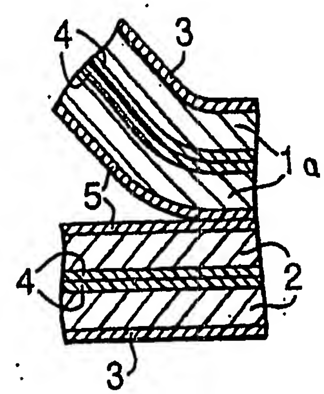


Fig.7.

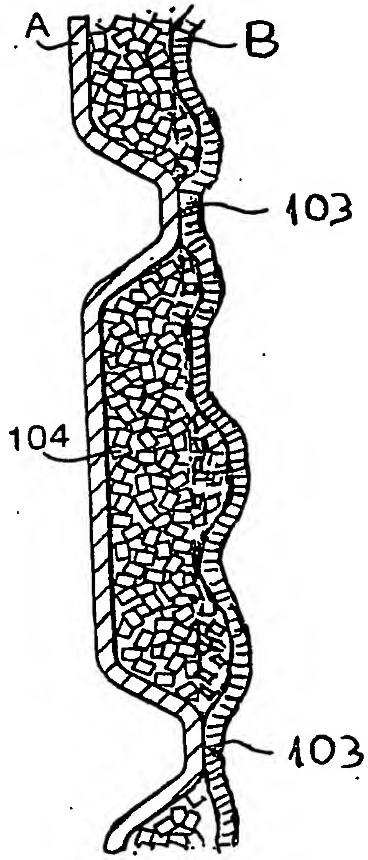



Fig.8.

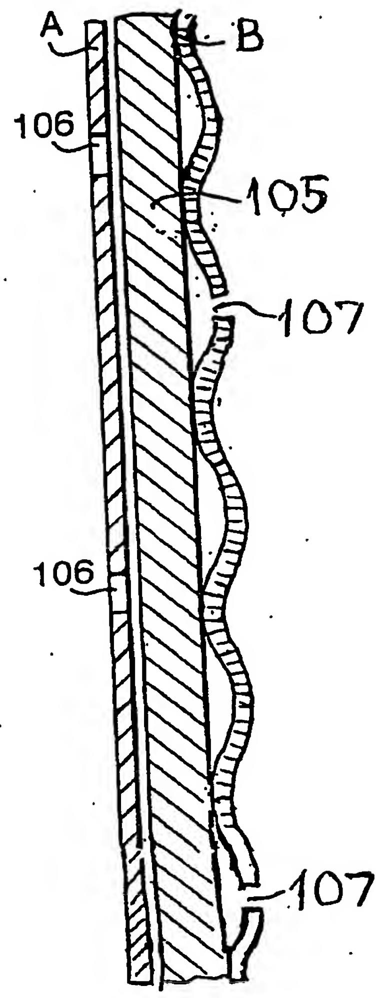



Fig.9.

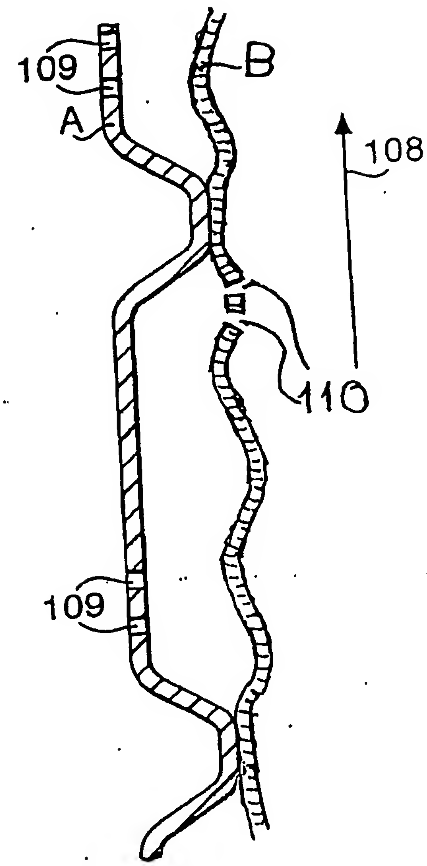


Fig.10.

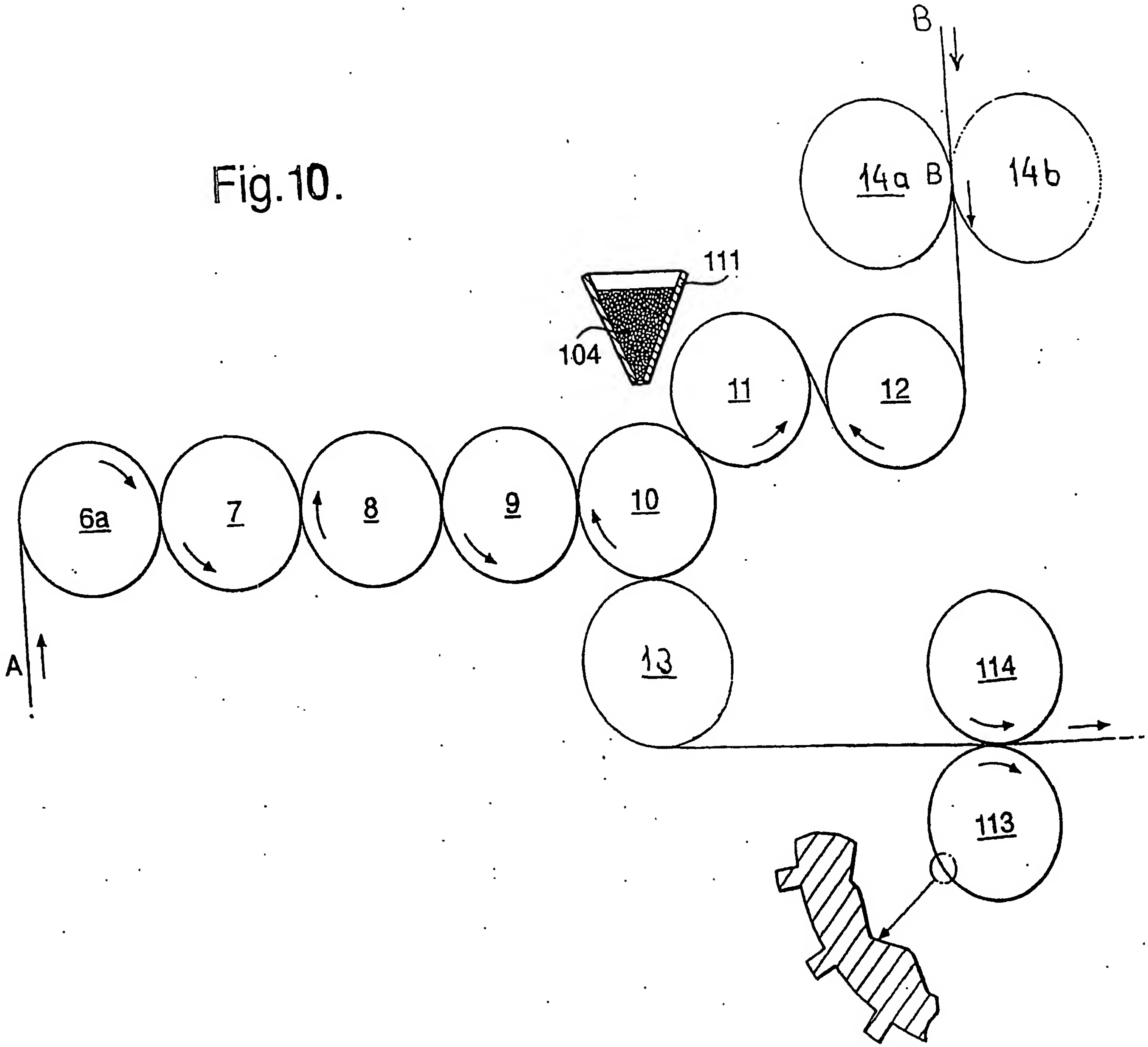


Fig. 11.

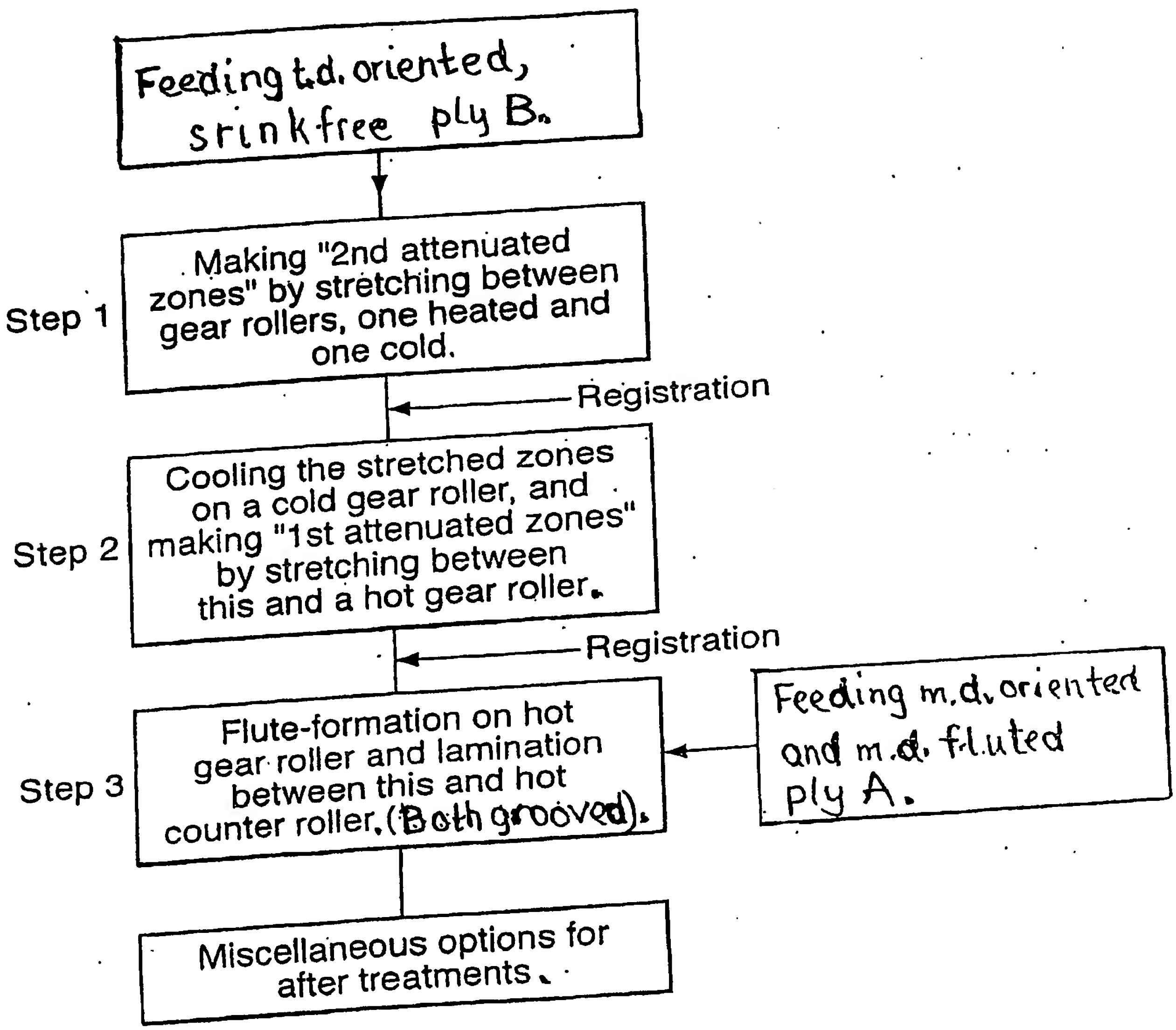
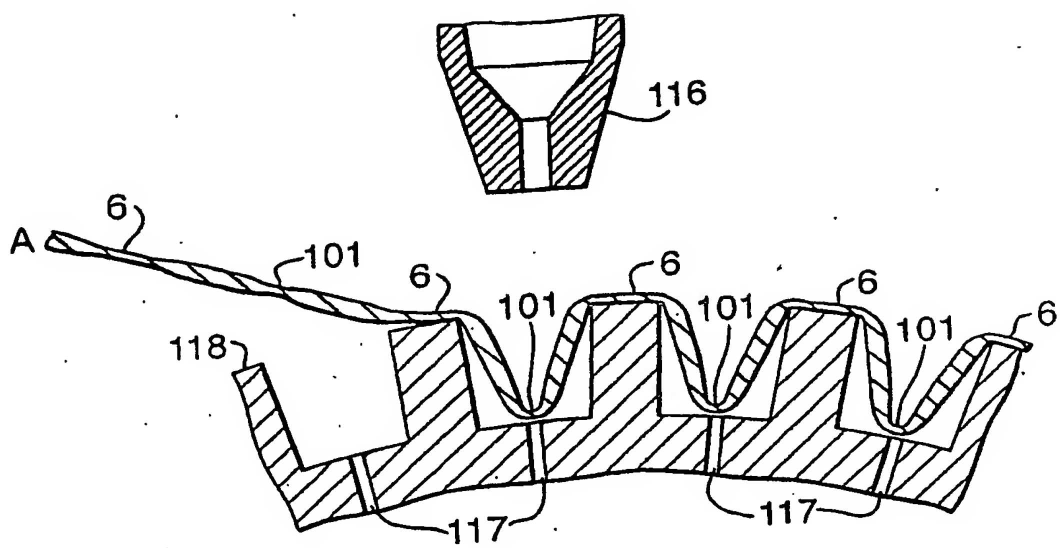

Feeding t.d. oriented, srinkfree ply B.
Step 1
Making "2nd attenuated zones" by stretching between gear rollers, one heated and one cold.
Registration
Step 2
Cooling the stretched zones on a cold gear roller, and making "1st attenuated zones" by stretching between this and a hot gear roller.
Registration
Step 3
Flute-formation on hot gear roller and lamination between this and hot counter roller. (Both grooved).
Feeding m.d. oriented and m.d. fluted ply A.
Miscellaneous options for after treatments.

Fig. 12.



PCT Application
PCT/EP2003/015001